LARVAL DEVELOPMENT OF THE POND SMELT, HYPOMESUS OLIDUS (PALLAS).

LARVAL DEVELOPMENT OF THE POND SMELT, *HYPOMESUS OLIDUS* (PALLAS)*.

By

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(*Recieved January 10, 1952*)

A knowlege of habits of fishes during their larval life is very important in order to analyse the fluctuations of fish population in natural waters. But, because of the difficulty in obtaining the larval fishes of successive stages in nature, there are only a few reports on the habits of larval fishes of various types. The pond smelt is often used for stocking in natural inland waters in Japan, and it is one of the most important natural fishes in its amount of catch. As a result of artificial rearing, the author could follow the change of feeding habits among successive stages of larval development of the pond smelt (Sato, 1950). In this paper, the morphology of the larval development of pond smelt and its bearing on feeding habits during the cource of the artificial rearing experiment will be reported.

I wish to express my hearty gratitude to Prof. T. Imai for his kind direction and encouragement and to Mr. S. Suganami for his help during the experiment.

Materials and methods

Nearly ten thousands newly hatched larvae of pond smelt were reared in a pond with an area of 40 square metres and a depth of 50 centimeters. The pond water was inoculated with planktonic organisms collected from another pond. The larvae of pond smelt were found to feed on *Brachionus bakeri* besides unicellular algae in their early larval life, and as they grew bigger they began to take larger organisms in the order of nauplius larva of *Cyclops sp.*, *Bosmina coregoni* and finally adult forms of Cladocera. After 47 days of rearing, 420 youngs

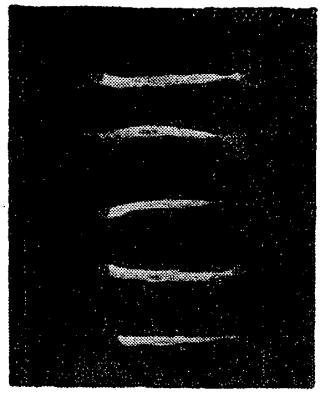

Fig. 1. Youngs on 32th day after hatching.

* Contribution from Onagawa Fisheries Laboratory.

with an average length of 20.9 mm. were obtained (Fig. 1). The rearing was continued until the 166th day when they reached 75 mm. in total length. Thus it was possible to follow the larval development of pond smelt for a considerably long period on an exact time basis.

Observations

1. Development of external characters

In the rearing experiment just referred to, the larvae of pond smelt showed a normal growth as is shown in Table 1.

Table 1. Growth of the larva of pond smelt in the rearing pond.

Days after hatching	0	4	6	11	15	17	21	25	32	42	47	66	128	166
Average of total length in mm.	5.9	6.2	6.5	7.2	7.9	8.5	8.7	10.4	12.6	17.9	16.2	28.3	54.0	75.0
Number of fishes measured	5	2	16	6	10	4	3	7	5	6	79	3	1	1

Artificially fertilized eggs hatch on the 18th day at 14°C. Newly hatched larva is transparent, and it has the pectoral fins developed to a greater or lesser extent. It has also a continuous vertical fin-fold all around the body from the back of the head, around the tail and along the lower edge of the body as far forward as the yolk sac. This fold is a simple membrane, and has no rays provided. The mouth is not formed yet (Fig. 2, A). Under such condition nourishment is supplied by the remains of the yolk. But as the yolk is consumed the mouth begins to develop. The larva, of 4 days old and of about 6.2 mm. in length, begins to feed on the planktonic organisms such as a rotifer, *Brachiomus bakeri,* besides unicellular organisms. And at this stage no gill-fillaments are developed yet (Fig. 2, B). At a later stage, the continuous median fin splits into its definitive components, namely, dorsal, adipose, caudal and anal fins. The vertical fin-fold of the abdomen disappears in fishes of 12.0 mm. in length and of 32 days old. And at a later stage the new ventral fin develops on the position at the same stage. The gill filaments begin to protrude beyond the gill slit (Fig. 2, C, D, E). Gradually, the body form, and dimensional proportion of the adult fish are attained, and, as a rule, all the essential organs, including the internal bony skeleton, develop before the fish reaches 30 mm. in length and 66 days old. The black pigments i. e. chromatophores also begin to appear along the head and dorsal portion of the body at this stage (Fig. 2, F).

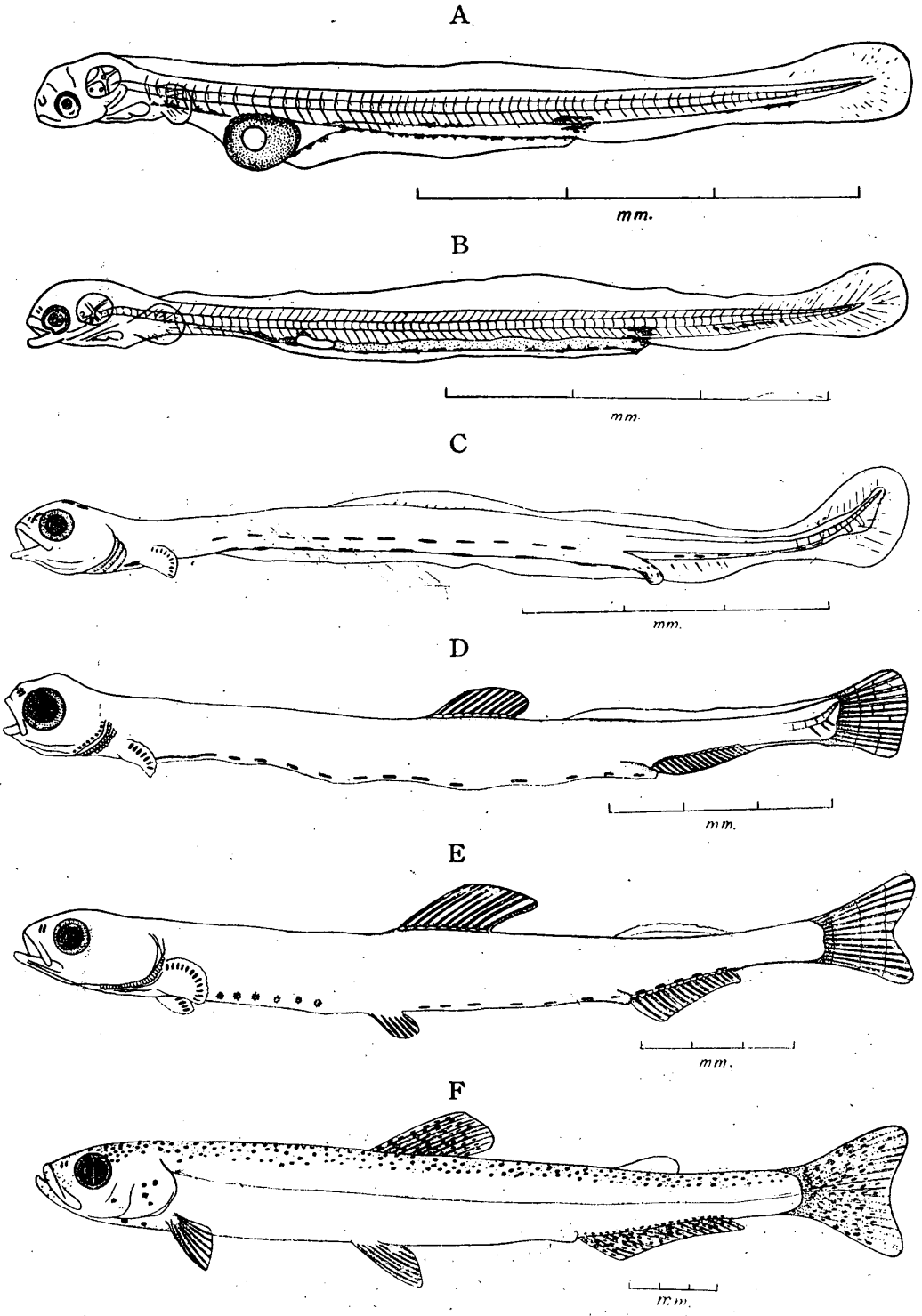

Fig. 2. Successive stage of development of the pond smelt, *Hypomesus olidus* (pallas). A, pro-larva just hatched, 60mm. in length; B, post-larva, 7 days old and 6.8mm. in length; C, post-larva, 21 days old and 8.7mm. in length; D, post-larva, 32 days old and 12.5mm. in length; E, post-larva, 47 days old and 17.5mm. in length; F, young, 66 days old and 30.0mm. in length.

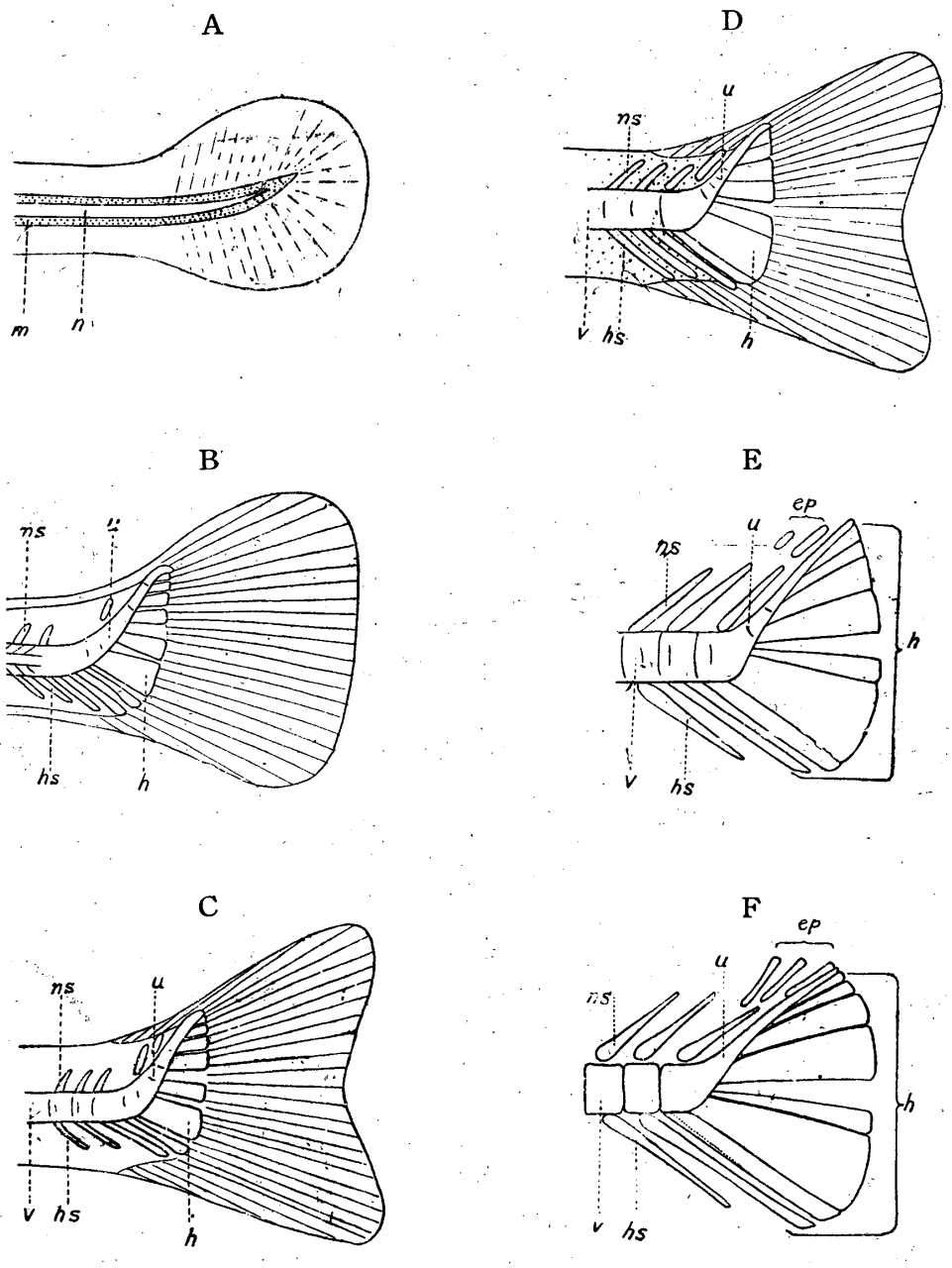

Fig. 3. Development of the caudal vertebrae.
A, from the specimen of 5.5mm. long; B, from the specimen of 11.0mm. long; C, from the specimen of 13.0mm. long; D, from the specimen of 19.5mm. long; E, from the specimen of 27.0mm. long; F, from the specimen of 45.0mm. long. ep, epurals; h, hypurals; hs, haemal spine; m, muscle; n, notochord; ns, neural spine; u, urostyle; v, vertebra.

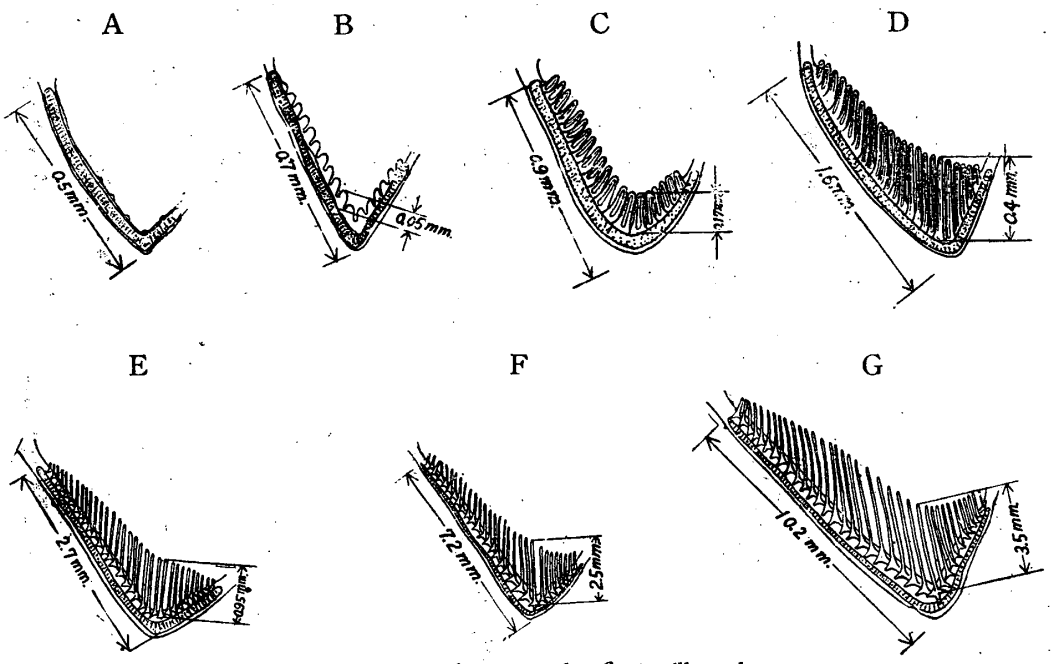

Fig. 4. Development of the gill-rakers on the first gill arch.
A, from the specimen of 8mm. long; B, from the specimen of 10mm. long; C, from the specimen of 17mm. long; D, from the specimen of 21mm. long; E, from the specimen of 30mm. long; F, from the specimen of 66mm. long; G, from the specimen of 75mm. long.

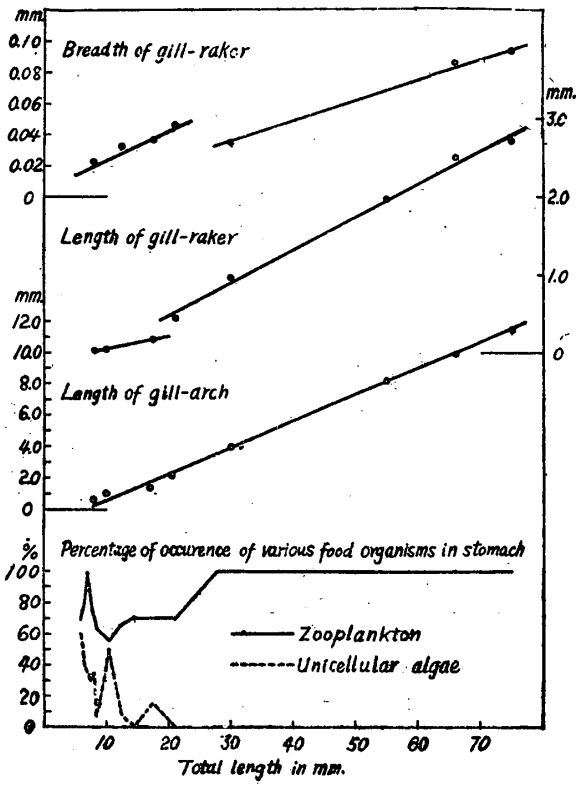

Fig. 5. Showing the relating between the development of gill-rakers and change in food organisms.

2. Development of the caudal vertebrae

In the tail of the pro-larva, the vertical fin-fold which lacks fin-rays is truly diphycercal (Fig. 3, A). The posterior end of the vertebral column, the caudal vertebrae, soon commences to bend upward. And numerous hair-like rods make their appearance along the lower edge of the axis, and the heterocercal tail is formed (Fig. 3, B). At a later stage, however the bending of caudal vertebrae becomes more conspicuous, and a symmetrical tail is finally formed with the degeneration of the anterior portion of upper lobe and an enlargement of lower lobes. The bent caudal vertebrae unites together to form a urostyle. Eight flat bones, hypurals, are completed along the lower edge of the urostyle at the stages of 26.0-32.0 mm. in length (Fig. 3, C, D, E, F). The morphology of caudal vertebrae development just referred to resembles that of other Isospindylous fishes such as herring, *Clupea harengus,* and red salmon, *Oncorhynchus nerka* (Kyle, 1926 and Aikawa, 1949).

3. Development of the alimentary tract

The mouth is developed and stomodium open to the intestine as the yolk disappears when fishes reach about 6.2 mm. in length, and the larvae begin to feed on the planktonic organisms.

No gill-rakers are formed on the gill-arch until the larva reaches about 8.0 mm. in length. The rakers which show first appearance at this stage are a few simple projections (Fig. 4, A). At 10.0 mm. stage the rakers become a little elongated and their number increased to 17 in first gill-arch (Fig. 4, B). And at 21 mm. stage the rakers are further elongated and they amount to approximately 24 in number. They are still blunt and broad projections with almost no space between them (Fig. 4, C, D).

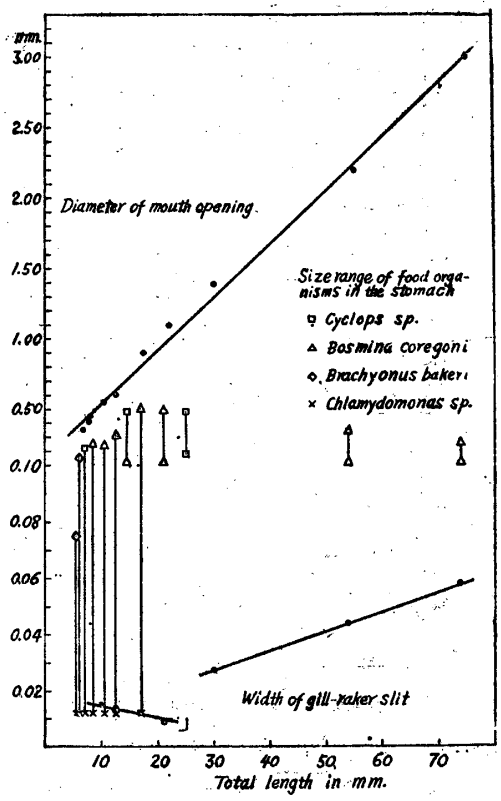

Fig. 6. Showing the relation between width of gill-raker slit and composition of food organisms in the stomach.

This implies that minute organisms such as unicellular algae would be also ingested along with zooplanktons. Namely with the undeveloped gill-rakers of this type the fish will be unable to select zooplanktons from the minute unicellular organisms, as is seen from Fig. 4. At the stage of 30 mm. and over, the pond smelt possesses 30 or more rakers. At this stage the rakers become very slender, and a fine comb-like structure is formed with a space of about 0.027 mm. between rakers (Fig. 4, E, F, G). The larva of this stage can take zooplanktons selectively from minute unicellular organisms as is shown in Fig. 5 and 6.

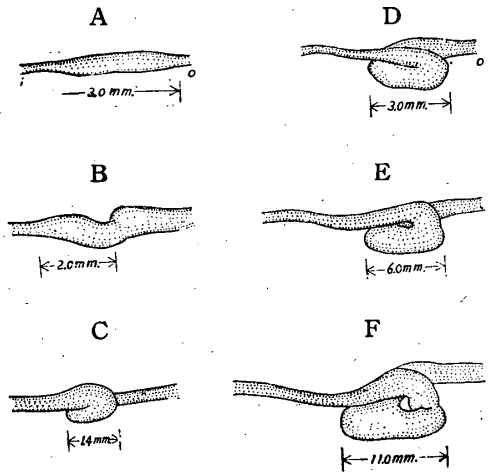

Fig. 7. Development of the stomach.
A, from the specimen of 15mm. long; B, from the specimen of 18mm. long; C, from the specimen of 25mm. long; D, from the specimen of 26mm. long; E, from the specimen of 48mm. long; F, from the specimen of 75mm. long.

The digestive tract of the early larva is a strait tube and no bending occurs until the larva reaches about 18.0 mm. in length (Fig. 7. A, B), when the tract begins to bend at its anterior portion. At 25 mm. stage, the tract formes a loop and the stomach is formed (Fig. 7, C, D). The stomach is divided into two portions, cardiac and pyloric portions, at the stage of 30.0 mm. or over in length (Fig. 7, E, F).

Conclusion and discussion

Newly hatched larvae are of elongated shape with about 6.0 mm. of total length. They are a little smaller than that of an allied fish, "Ayu", *Plecoglossus altivelis* (Fish. Exp. Stat. of Tokyo, 1936 and Kataoka, 1940). As the yolk is consumed, the mouth is developed. The larvae of 7 days old and 6.8 mm. long begin to feed on the planktonic organisms such as rotifer, *Brachionus bakeri*, besides unicellular algae.

The external characters of early stage of pond smelt resemble closely that of other Isospondylous fishes. In the post-larva of 8.7 mm. or over, however, they can be distinguished clearly from others such as silvery-anchovy, *Spratelloides japonicus* (Hukuda, 1936), and sardine, *Sardina caerulea* (Scofield, 1934). The dorsal fin of the pond smelt at this stage is situated in the mid portion of the body instead of the posterior portion as in silvery-anchovy

and sardin. Another characteristic feature is the presence of the adipose fin in the case of the pond smelt. The pond smelt also resemble in the external characters the Japanese salanx, *Salangichthys microdon.* The salanx has a similar breeding season to that of pond smelt. It also possesses an adipose fin. But it can be distinguished from the pond smelt by the position of the dorsal fin which is in the posterior portion of the body and also by the depressed shape of the head. At the stage of 66 days old and 30.0 mm. long, the structure of the adult fish is assumed and, as a rule, all essential organs are developed. The gill-rakers become very slender and form a fine comb-like structure, though no processes which were seen in the sardine (Scofield, 1934) are developed. The development of this type of gill-rakers at this stage enables the fish to select the zooplanktons out of the minute unicellular organisms. Kokubo (1949) found in Lake Kogawara that the pond smelt of over 30.0 mm. in length takes exclusively the zooplankton as food. Miyauchi (1934) and Ishida (1949) have also reported the same result from an analysis of stomach contents in the adult pond smelt collected from Lake Kasumigaura and Lake Abashiri. Namely in the case of pond smelt, the gill-rakers develop so as to enable the fish to select large zooplanktonic organisms from small phytoplanktons. Such change of food habit during development in the pond smelt is contrary to the case of California sardine in which, according to Scofield (1934), the fish becomes able to take phytoplanktons such as diatoms as well as zooplankton as the gill-rakers are completed with accessary processes.

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